The Temijbek ichnological site from the Early Pleistocene of the Caucasus foreland (Russia): Taphonomy and identification of fossil burrows

Dmitri Ponomarenko

Mammals Lab, Borissiak Palaeontological Institute, Moscow, Russia

d.ponomarenko@paleo.ru

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Introduction

Although fossil burrows have long been known to occur in the Pleistocene paleosols of the steppes of Eastern Europe, they have received only a cursory mention in geological descriptions. No ichnological sites with fossil burrows have previously been described here. In this paper, we give the first description of a fossil burrow ichnoassemblage from this region. The young age of the locality presents an opportunity to identify burrows by reference to burrows of extant species of the same genera (Ponomarenko & Ponomarenko 2018). Additionally, the study of preservational features and forms of burrows is instructive for the interpretation of older fossil burrow localities.

Geological Location

The Temijbek fossil locality occurs within the Early to Late Pleistocene section exposed in the Kuban River bend of the Caucasus foreland (Dodonov et al. 2006). The lower half of the section consists of alluvial deposits and hydromorphic paleosols which have been dated from scarce small mammal fossils (*Clethrionomys* cf. *kretzoii*, *Mimomys reidi*, and *Mimomys* sp.) to the Gelasian (Tesakov 2010). In addition to skeletal fossils, which occur in the lower, alluvial deposits, the section contains paleosols with ichnofossils, called "calcified krotovinas" by Dodonov et al. (2006), but previously undescribed. Fossil burrows occur in two carbonate paleosols in the middle of the section, intercalated between colluvial deposits, at the transition from hydromorphic to automorphic soils. These paleosols have a reverse magnetic signature (Matuyama) and are dated to the late Calabrian (ca. 1 Ma). Overlying the middle part of the section are Upper Pleistocene loessic deposits with paleosols without calcified fossil burrows.

Another paleosol with carbonate fossil burrows was found during our fieldwork in 2017 within a previously undescribed outcrop 2 km upstream of the described locality. The exact stratigraphic correlation of this outcrop with the dated section is yet unclear. A colluvial sedimentology including carbonate paleosols point to a Calabrian age coeval with the dated burrow-bearing paleosols.

Materials and Methods

32 fossil tunnel casts were documented in the field, 12 tunnel casts were collected for further study. In describing and identifying the fossil burrows we made use of the reference collection of mammal burrow casts at the Borissiak Paleontological Institute and our descriptions of subrecent burrows observed in archaeological, geological, and soil sections. The taxonomically diagnostic features identified from these two sources have been described in another paper (Ponomarenko & Ponomarenko 2018). The reference collection includes burrows of the following mammal taxa: Insectivora: Talpidae (*Talpa europea*, *Parascalops breweri*), Rodentia: Spalacidae (*Myospalax myospalax*, *Spalax microphthalmos*), Sciuridae (*Marmota monax*, *Tamias striatus*, *Spermophilus fulvus*, *S. major*), Cricetidae (*Ellobius talpinus*, *Cricetus raddei*, *C. cricetus)*.

Results

The studied fossil burrows occur as carbonate-permeated infills. The degree of cementation varies from complete cementation of the entire infill to carbonate rims from precipitation along the interface between the infill and the encasing material. In modern climatic conditions of the Kuban River valley, calcrete does not form within the burrow fill, but similar processes are known from slightly more arid conditions (e.g., see Imbellone, Teruggi 1988). The burrowed paleosol levels contain both Mg concretions and carbonate nodules, which indicates rapid drying of water-logged deposits.

The structure of the bioturbation horizon is different in the three studied paleosols. The upper paleosol in outcrop 1 contains a shallow bioturbation horizon (25–30 cm), which has to do with the predominance of dense horizontal tunnel networks. The lower bioturbation horizon in outcrop 1 (Fig. 1) is 150–180 cm deep and is crossed by both inclined and subvertical, in addition to horizontal, tunnels. In outcrop 2, the visible bioturbation horizon is 40–50 cm deep, dominated by chambers with a smaller number of horizontal and subvertical spiral tunnels. The horizon is truncated at the top and possibly covered by talus below.

Five morphological types of fossil burrows occur in the locality:

1. Horizontal, vertical and rarely inclined tunnels. Diameter 6.0–8.0 cm. Vertical tunnels gradually level out into deep horizontal tunnels below. No chambers found. cf. *Nannospalax* (Fig. 2).
2. Tunnel diameter 8.5–9.5 cm with chambers up to 12 cm. Bends 20–40 cm long. Elliptic cross-section, height > width. Sculpture contains paired divergent crests 10–15 mm long. cf. *Spermophilus* (small species) (Fig. 3).
3. Cross-section strongly asymmetrical, height >> width (12×7 cm). A single straight inclined tunnel found. If the cross-sectional shape reflects the shape of the original tunnel, then even in the absence of other morphological features the tunnel should be identified as a jerboa species similar to *Allactaga major* in size. The shape and size of the cross-section correspond to the shape of jerboa entrances (Fenyuk 1928, 1929).
4. Surficial tunnels within the upper carbonate burrow-bearing paleosol. Diameter strongly variable, from 4.5 to 8.0 cm. No vertical or inclined tunnels were found, tunnels occur in a dense network. In the absence of other features it is referred to Arvicolidae.
5. Spiral vertical tunnels, horizontal tunnels, chambers (Fig. 4). Diameter: vertical tunnels 5.5–6.0 cm, horizontal 6×7.5 (width > height). The only species having this kind of spiral tunnel in the studied region is the mole-vole, *Ellobius* (see Ponomarenko & Ponomarenko 2018).

Conclusion

From fossil data it is known that small mammal fauna of the studied region during the Eopleistocene was similar to the present. The fossorial rodents were represented by modern genera. The particularity of the Temijbek locality is the occurrence of a large variety of burrow morphotypes within a small outcrop area. The large diversity of fossil burrows likely reflects changing conditions over the lifetime of the paleosol, rather than a strictly contemporaneous assemblage. No skeletal fossils have so far been described from the paleosols, and the diversity of taxa represented by burrows (5) is larger than the diversity of skeletal fossils in the underlying alluvium (3). The taxonomic diagnostics of fossil burrows within paleosols therefore directly complements the skeletal fossil record. Given the state of preservation of the Eopleistocene burrows in the Kuban River valley, the most important tools for burrow diagnostics are architecture, followed by diameter and sculpture.

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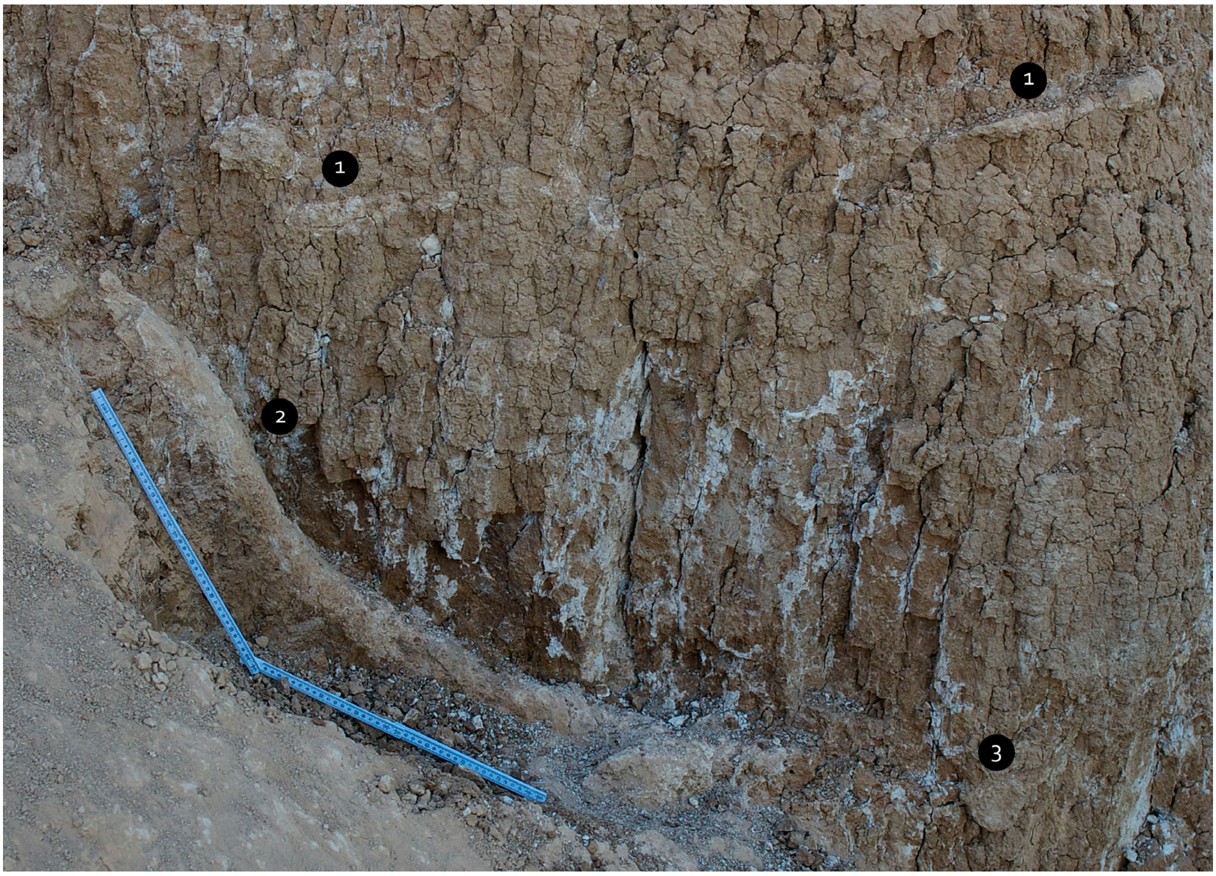

Fig. 1. Outcrop 1. Portion of the bioturbation horizon: 1) inclined tunnels, 2) subvertical tunnel, 3) deep horizontal tunnel of morphotype 1.

Fig. 2. Temijbek fossil burrow morphotype 1. Inclined and horizontal burrows in outcrop.

Fig. 3. Temijbek fossil burrow morphotype 2 in plan view. Bends and sculpture.

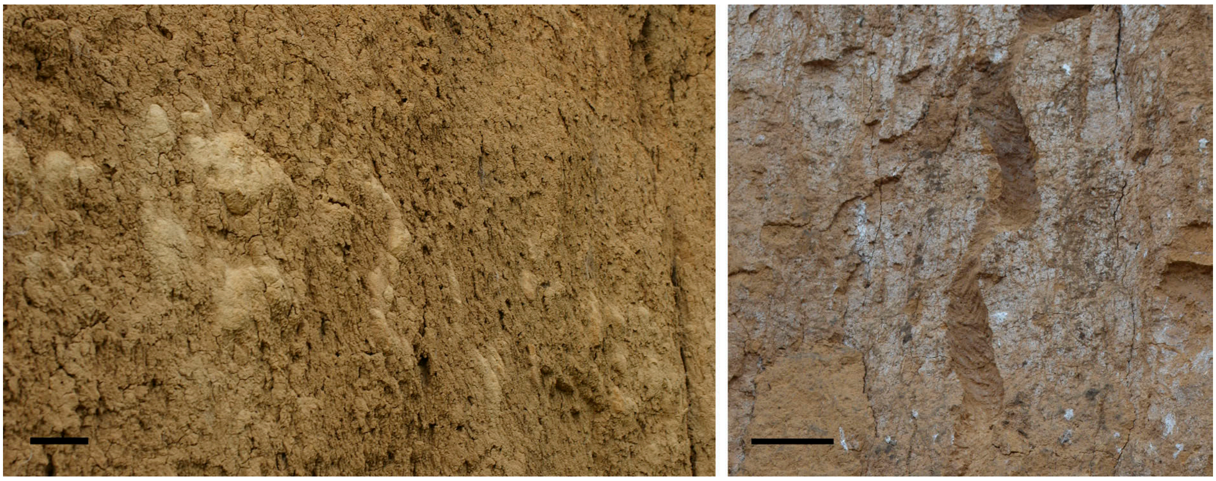

Fig. 4. Chambers and spiral subvertical tunnels. Left, Temijbek locality, outcrop 2, morphotype 5. Right, subrecent *Ellobius talpinus* spiral tunnels (confluence of the Kama and the Volga Rivers).